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Correspondencia: Departamento de Ciencias Ambientales y
Recursos Naturales. (División de Geología)
Facultad de Ciencias de la Universidad de Alicante
Teléfono 566 11 50. Extensión 1.190
Apartado 99 ALICANTE

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THE N/Q BOUNDARY AT 1.64 MA ? *

por
FRANCESCO PAOLO BONADONNA [1]
MARIA TERESA ALBERDI [2]

RESUMEN

El límite N/Q establecido en Vrica muestra muchos defectos que, en nuestra opinión, le restan utilidad como límite geocronológico. Hay evidencia, en el registro tanto marino como continental, de una primera glaciación en el Hemisferio Norte entre 3,1 y 2,4 MA. En ese tiempo, una agrupación florística de clima frío, el evento «estepa», se encuentra tanto en las series marinas como en las continentales. Desde el punto de vista de la fauna continental, hay un claro recambio de los vertebrados entre el Villafranquiense inferior *(Mastodon, Hipparion)* y el Villafranquiense superior *(Elephas, Equus)*. La transición tiene lugar en el Villafranquiense medio (2,6-2,4 MA), donde aparecen *Elephas* y *Equus* primitivos. La edad del límite de Vrica, de 1,64 MA, fue obtenida asumiendo una velocidad de sedimentación uniforme (310 mm/1000 y) y teniendo en cuenta que este límite está un metro por encima de la transición de polaridad paleomagnética normal-inversa identificada de manera cuestionable como techo de la subzona Olduvai (1,67 MA). Esto implicaría una resolución temporal florística-faunística mejor de 30 ka. Finalmente, los resultados palinológicos e isotópicos muestran, en ese momento, pequeñas oscilaciones en lugar de un gran cambio climático. De esta manera los argumentos a favor del límite de 1,64 MA son poco convincentes desde un punto de vista paleontológico, cronológico, paleomagnético y paleoclimático. El límite N/Q, para que las series continentales de Europa noroccidental, es considerada por muchos autores entre 2,5 y 2,3 MA.

ABSTRACT

The N/Q boundary as established in Vrica shows several defects which, in our opinion, detract from its utility as geochronological boundary.There is evidence, in the marine and continen-

[1] Dipartimento di Scienze della Terra, Università di Pisa - Via Santa Maria 53 - 56100 PISA (Italy).

[2] Museo Nacional de Ciencias Naturales, C. S. I. C., José Gutiérrez Abascal, 2. 28002-MADRID (Spain).

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tal climatic record, of a first glaciation in the Northern Hemisphere between 3.1 and 2.4 MA. At that time, a cold floral assemblage, the «steppe» event, is found in marine and continental series. A less important «steppe» event is reported from the Eburonian and during the Aulla erosional phase (1.8-1.6 MA). From the point of view of continental fauna, there is a clear turnover of vertebrates between the Lower Villafranchian (*Mastodon, Hipparion*) and the Upper Villafranchian (*Elephas, Equus*). The transition took place in the Middle Villafranchian (2.6-2.4 MA), with primitive *Elephas* and *Equus*. The Vrica boundary age of 1.64 MA was obtained by assuming an uniform sedimentation rate (310 mm/1000 y) and noting that the boundary is 1 metre higher than the normal to reversed polarity transition questionably identified as the top of Olduvai 1.67 MA old. This would imply an unlikely resolution of floral-faunal boundary better than 30 ka. Finally, palynological and isotopic results show small climatic oscillations rather than a strong climate transition. Thus the arguments for a 1.64 MA boundary are unconvincing from paleontological, chronological, paleomagnetic and paleoclimatic viewpoints; furthermore, the N/Q boundary in the continental series of northwestern Europe was considered by many authors to be at 2.5-2.4 MA.

KEYWORDS: Quaternary Stratigraphy, N/Q Boundary, Vrica section, Biostratigraphy.

INTRODUCTION

During 1984 the ICS Commission wrote a resolution in which the N/Q Boundary was stated. The resolution repeated, almost integrally, the one approved in Moscow during the XI INQUA Congress by the members of INQUA Commission for the Boundary and by the members of the IGCP Project n. 41 Executive. The Moscow resolution was approved whit 13 votes, 2 abstentions and 1 vote against. The difference between the two resolutions was the quotation of *Cytheropteron testudo* considered as northern guest coeval to *Arctica islandica* in Moscow one. Furthermore in the ICS resolution the age of N/Q Boundary is fixed in a too precise value to be believable, but on this point we shall return later after. First of all we wish to discuss a little the state of the art of the problem of the N/Q Boundary in the world and particularly in Italy.

In 1948 INQUA Congress resolution fixed the place and the criteria with which the N/Q Boundary would be studied. The authors of the 1981 Moscow resolution have worked bearing in mind those recommendations: in the London Congress, Italy, particularly Calabria, was considered as the appointed place for the N/Q Boundary, as in Calabria GIGNOUX in 1913 founded the Calabrian stage; but until 1952 Alger Congress, GIGNOUX considered the Calabrian as not being the beginning of the Quaternary cycle. Furthermore from 1975 RUGGIERI and SPROVIERI (1975 a y b, 1977, 1979a y b) consider the Calabrian invalid as a stratigraphic name, as synonymous of Sicilian stated by DODERLEIN (1872) on Ficarazzi clays near Palermo (Sicily).

As we think the researcher has to be strongly selfcritical (the satisfaction for one's own results is typical of applied science only) and that the research can go on only refuting itself, we cannot comprehend as for «historical» or «traditional» reasons what we could go on to prove as incorrect by successive researches: that is, to persevere in research of the N/Q Boundary in Calabria, when it was proved that GIGNOUX's Calabrian was not representative of the first Pleistocene sediments, and, furthermore, not taking into account the other two sections (S. Maria di Catanzaro and Le Castella) topographically very near to the Vrica section, completely studied by scientists from all over the world, were proved as unqualified to represent the N/Q Boundary stratotype for geological and regional reasons. But we leave to the specialists the polemic on the section and on the good fossil determinations (JENKINS, 1987; WHATLEY, DOWNING in press); we wish to discuss only the criteria followed in defining the 1984 N/Q Boundary.

THE DATA

First we have to see which data we have to take into account to define a geological boundary, or better, which elements we have to consider as important to state it. The present reasoning which considers a paleontological well-defined section as a starting point, in our opinion, would be totally unsuitable; also, as the coevity of paleontological data all over world and especially in all the environments is not well proved. In our opinion the starting point would have to be the «geological» datum; with this word we mean the all totality of paleoclimatic, sedimentologic, paleomagnetic, tectonic and paleontologic data which left its mark on Earth's evolutionary history: furthermore, some of these data, like the paleoclimatic or the paleomagnetic ones, can be considered as «exportable», regarding the coevity, throughtout the world. After being sure of the «geological» datum, and after having fixed by radiometric and paleomagnetic measurements the age of the datum, at this moment one would try on different geological sections in which the datum is registered, to detail the paleontological researches to furnish other evidence to allow for a definition of the boundary in all the world; we have furthermore to take into account that this method could be allowed some paleontological data are coeval or diachronic. The opposite method, instead, has made the boundary value incredibly ambiguous, so that it now cannot represent a firm point in the geochronological scale. We have to add that the age measurements have shown that also the «geological» events are sometimes, on the global scale, not totally synchronic; that is, every geological boundary is geographically diachronic. The N/Q boundary fixed by INQUA Commission in Vrica, on the contrary, is stated, with a debatable method, at 1.64 MA (AGUIRRE, PASINI, 1985), different by the top of Olduvai normal magnetic subzone of 30 ka, implicitly furnishing to the floral and faunal events a temporal resolution of 10 ka! FLYN et al. (1984) show instead, that if a biostratigraphical event happens in a precise magnetic subzone, generally its temporal resolution for is equal to 3.3×10^5 years and particularly for the Neogene events the temporal resolution for biostratigraphical datum is in the order of 10^5 years indifferently

if the datum age is obtained by radiometric or paleomagnetic measurements. But this very young age for the N/Q Boundary, by its artificial precision, is in great disagreement whit the «geological» data in throughout the world. ZAGWIJN (1985, pag. 18) argues the «*duration of the Quaternary in the Netherlands was much longer than had been thougth, namely about 2.3 million years*»: his arguments are principally based on climatic data on pollen spectra and on paleomagnetic research (MONTFRANS, 1971). The same age was also confirmed by the paleoclimatic research (SUC & ZAGWIJN, 1983) on a more extended region than the Netherlands, comprehending also the Mediterranean region. In this work the authors affirmed that the first appearance of steppe flora in the region, an appearance that shows the climatic change, coincides with the Praetiglian stage that «is the first interval which deserves to be called glacial» (SUC & ZAGWIJN 1983, pag. 155). The same results are later repeated by SUC (1982, 1984) who argues that the appearance of mediterranean seasonal cycles is at 3.2 MA while the first glacial cycle, by which time we have the beginning of mediterranean vegetational associaton, is at 2.3 MA. From the point of wiew of European mammalofaune the faunistic turnover between Montopoli fauna and Olivola seems very astonishing. But this evidence is only supported by the fact that Montopoli and Olivola faunas are not adjacent from a chronological point of view. In fact the Olivola fauna is not coeval to the beginning of the new cycle characterized in the sea by the appearance of northern guests; it is representative of a successive time as proved by FOLLIERI (1977) by pollen spectra on Monte Mario (Rome) sections with *Arctica islandica* and on Upper Valdarno sections with Olivola fauna: that is, Olivola fauna cannot represent the beginning of Quaternary mammal fauna. In fact between Montopoli and Olivola faunas, St. Vallier fauna is missing (table 1); this last fauna, in our opinion, is present in Italy in the S. Giacomo deposit (BIDDITTU et al., 1979) as supported by ALBERDI & BONADONNA (1983) and BONADONNA ALBERDI (1987) and also suggested (with reservation by the DE GIULI et al. (1984) and by MALATESTA (1985, pag. 220). The examinations of its faunistic list shows the contemporary presence of old faunistic forms like *Croizetoceros ramosus, Anancus arvernensis, Gazella borbonica* as well as new forms such as *Sus strozzii, Dicerorhinus etruscus* and *Canis* cfr. *etruscus* a primitive wolf (TORRE, 1976). The appearance of this last form marks, according to AZZAROLI (1983), the «wolf event», the age of which would be not so easy to define (AZZAROLI, 1983), and by the which AZZAROLI gives a doubtful age of 1.7 MA to the Olivola fauna, very near to the N/Q Boundary age stated in Vrica. Out of the querelles on the names of Middle and Upper Villafranchian, on the results of pollen spectra (FOLLIERI, 1977) and considering the «wolf event» a consistent paleontological datum, this consistency itself discredits such an early age (1.64 MA) for the N/Q Boundary. It is founded on the appearance (it is possible to read in the INQUA and ICS resolution) of northern guests coeval to *Arctica islandica* (in the following we shall see that this statement is, in that context, without foundations); but in Monte Mario (Rome) *Arctica islandica* appears before the Olivola fauna hence of the «wolf event»; so this faunistic datum cannot represent the beginning of Quaternary faunas, or the faunistic associations of mammals, today considered by some authors as Quaternary fauna, are not coeval to the appearance of nort-

hern guests in the Mediterranean region. But we think that the age of this event may be considered older without problems, while being discordant with the artificial value of Vrica age. The first appearance of *Canis etruscus* would be in St. Vallier fauna (older than 2 MA) proposed as the beginning, in the continental series, of the Quaternary cycle (BONADONNA & ALBERDI, 1987) on the quotation of BIDDITU et al. (1979): so considering the «wolf event» older than the age fixed by LINDSAY et al. (1980) and AZZAROLI (1983), that is attributing to it an age as the one of St. Vallier deposit (about 2.3 MA) the age of AZZAROLI's «wolf event» could coincide with the age fixed for the beginning of Quaternary in north western Europe. But, probably, to consider the «wolf event» as the beginning of Quaternary mammal fauna may be guessed at if we take into account the numerous quotations of *Canis* aff. *etruscus* in Lower Villafranchian of Vialette and Les Etouaires deposits (BOULE, 1910; KURTEN, 1963; FAURE & GUERIN, 1984) and of *Canis etruscus* in Podere del Tesoro deposit, Peccioli-Tuscany (TORRE, 1967) Lower Villafranchian in age. PONS & CRUSAFONT (1978) show a relationship between the Turolian form *Canis cipio* and *Canis etruscus*: these authors explain the scarcity of the last form in Pliocene deposits with different reasons like: 1) the lack of abundance of deposits of this period; 2) some ecological factors (may be a kind of competitivity) that may be considered as a negative effect: the same case that would be verified between *Nyctereutes megamastoides* and *Canis etruscus;* in fact the presence of *Canis etruscus* becomes more frequent after the extinction of *Nyctereutes megamastoides.* Also in different regions the most evident faunistic turnover is always reported near the paleomagnetic boundary Gauss-Matuyama (AZZAROLI, 1985); it is more marked than a variation in carnivorous fauna by the appearance or the disappearance of herbivorous ones, as, for instance, by the disappearance of *Hipparion* and the appearance of *Equus* or by the appearance of the first *Elephas.* Here we wish to include the E-L-E (*Mammuthus, Leptobos, Equus*) event, that is the big radiation from Africa, Asia and America of large steppic herbivorous animals that happens, according to STEININGER et al. (1985) during the zone MN 16 (Lower and Middle Villafranchian sensu BONADONNA & ALBERDI, 1987). The same climatic result was obtained (ALBERDI et al., 1982; LEONE, 1985) on Rincon series (southern Spain). From an isotopic point of view, measurements performed on carbonate sediments and fresh water gastropods have produced evidence of two cold periods after Lower Villafranchian fauna and before and during the Montopoli one, represented, also here, by large steppic herbivorous animals. The isotopic results show that between the two cold episodes there is a warm dry period; this climatic trend correlates well with the climatic trend shown by isotopic data in the marine environment at 3.2-2.4 MA. The Rincon data confirm the age of Montopoli fauna and the cold climatic period during the which it lived. We think it important to remember that, at the same time, another important faunistic event happens: the second Arvicolidae radiation called by STEININGER et al. (1985) the «*Mimomys* radiation». To remain in the micromammals event we find, also at the same time, the faunistic break quoted by REUMER (1984, fig. 3): the disappearance of a large number of Soricidae between the MN 16a and MN 16b zones in Central Europe: according to Mediterranean stratigraphic table, the zone MN 16a is represented by Triversa

fauna and the MN 16b by the Montopoli one. We can say therefore that, from the point of view of mammal faunas (macro and micro) an important faunistic turnover or break happens a little before or at the same age as the paleomagnetic boundary Gauss-Matuyama. The same indications of a break in natural events are found also around the same age, on the different bases of the continental or marine series. In the Pannonian basin RONAI (1985) shows a dry period at the end of Pliocene followed by a wet period that marks, in his opinion, the beginning of the Quaternary, but that, in any case, marks an important change in the natural conditions of the region. The link between these two different times is represented by sterile sediments testifying, according to the author's opinion, to the time deposition relative to some thousands of years due to successive flooding and drying processes of the basin; the climatic and floristic differences happen at an age very near to the Gauss-Matuyama boundary on the results of paleomagnetic research on drills more than a thousand meters deep. The N/Q Boundary in the continental China series (LIU TUNG-SHENG, DING MENG-LIN, 1985) is stated in Nihewan series in which Villafranchian type fauna is found. The series is divided into two parts; the lower one containing archaic fauna similar to Lower Villafranchian European fauna (LIU TUNG-SHENG, DING MENG-LIN, 1985) and the upper part whit the youngest fauna. The boundary between the two parts is marked by the Gauss-Matuyama paleomagnetic boundary. The same conclusions, always in China series, are shown by SONG ZI-CHIEN et al. (1985) by paleoclimatic researches on pollen spectra. The Author tests the first cooling, marked by a Conifera zone followed by a herbs zone (about 70 %) at an age around 2.6 MA. If we work on the marine series, all the paleoclimatic evidence attest to the first climatic cooling around 2.5 MA. BLAZHCISHIN & LIN'KOVA (1979) show the first glaciation of the Barent shelf at Gauss-Matuyama boundary on paleomagnetic measurements. THUNELL & WILLIAMS (1983, fig. 5) on six different cores of different regions of the world studied by different authors (Northern Pacific, DSPD Site 310, KEIGWIN, 1979; Equatorial Pacific, V 28-239 and 179, SHACKLETON & OPDYKE, 1977; Caraibi Sea, DSPD Site 502, KEIGWIN, 1982, PRELL, 1982; Cape Bojador, DSPD Site 397, SHACKLETON & CITA, 1979; Western Mediterranean, DSPD 132, THUNELL & WILLIAMS, 1983; Eastern Mediterranean, DSPD 125, THUNELL & WILLIAMS, 1983) show only two big climatic oscillations: the first, very strong at 2.5 MA and the second, less intense than the other, at an age a little less than 1 MA. The research in isotopic studies concludes that the growth of permanent ice in the Northern Hemisphere began 2.5 MA ago, in good agreement to BACKMAN (1979): but this theory is also supported by sedimentological research: the increase of eolic accumulation in the North Pacific Ocean at 2.5 MA, may only be attributed to an increase of atmospheric circulation linked to the growth of arctic ice (REA & JANACEK, 1982). The enrichment in ^{18}O at 3.2 MA may be attributed to different causes (THUNELL & WILLIAMS, 1983). SHACKLETON et al. (1984) studying the DSPD Site 552 A state the presence of two layers of ice-rafting debris at 2.5 MA and of a richer one at 2.4 MA. Furthermore SHACKLETON & HALL (1984) bear out that in DSDP Site 552 A there is evidence for the first glaciation in the Northern Hemisphere at an age of 2.4 MA, while the other data, suggesting a cooling from 3.2 MA

until 2.4 MA, were not enough to prove significant glaciation. All these data are in good agreement to the continental ones for which the first cold mammal fauna appear a little before the firts steppe event. The BERGGREN's data (1972) on DSDP LEG 16 Sites 111 and 116 that proved an age of 3.2 MA for the first ice-rafting debris in the North Atlantic region, are refuted by BACKMAN (1979) who, after an examination of the samples studied by BERGGREN, assign to it the younger age of about 2.5 MA. But, this is very interesting, SHACKLETON et al. (1984) also add a paleontological datum to the climatic data: the extinction of *Discoaster pentaradiatus* at the same age of the first ice-rafting debris (2.4 MA). Why this extinction cannot be used to define the N/Q Boundary when «*the extinction data, when defined in consistent manner, represent a more accurate means of correlations than evolutionary appearance datum*» (BACKMAN et al., 1983, pag. 157), it is not clear. But the use of a paleontological datum throughout the world without a good chronological control may be doubtful; for instance, in China plains AN ZHI-SHENG et al. (1979) in LIU TUG-SHENG & DING ME-LING (1985) state the N/Q Boundary, on paleomagnetic data coinciding with the Gauss-Matuyama inversion, at the base of *Hyalinea balthica* zone «*since Hyalinea balthica is a form of the Calabrian deposit in Europe*» and we know, by a very large amount of evidence, that in the Mediterranean region the appearance of *Hyalinea balthica* is at 1.5 MA or a little earlier. So the marine N/Q boundary in China may be right at 2.5 MA, but the paleontological argument used to state it are wrong. All data until to day reported, states that the first cooling event age in the sea as well as on the continents is in contrast to the Vrica proposed age. But some authors sustain that from a historical point of view this age is in agreement when considering the first cooling as coinciding with the appearance of the northern guests in the Mediterranean area. Also if we would consider this singular statement as correct, our opinion is that the N/Q Boundary proposed in Vrica is not in agreement to it. The excelent northern guest in the Mediterranean region, to which all the authors refer, is *Arctica islandica*; this fossil is not represented in Vrica, but the N/Q Boundary resolution states that at the same level of N/Q Boundary in Vrica a microfauna coeval to *Arctica islandica* appears. We try to verify this statement: the four sections in which *Arctica islandica* appears and for which we have paleomagnetic data, show its appearance always in a normal magnety polarity interval (Santerno, KUKLA et al., 1979; Stirone, BONADONNA, 1982; Collesalvetti-Tuscany, BEDINI et al., 1981; Ceppato-Tuscany INQUA Guide book 1975; BOSSIO et al., 1981): the Santerno section is considered constituted by batial sediments with turbiditic intercalations in which neritic shells, as *Arctica islandica*, are found (RUGGIERI, 1976). This fact allow us to see its appearance very early (RUGGIERI, 1976) together with the appearance of left coil *Globigerina pachiderma* (COLALONGO, 1970); but this means that these appearances happen in a normal magnetic interval and hence not coeval to the same appearance of left coil *Globigerina pachiderma* in Vrica section as here its FAD and the proposed Boundary fall in a reversal magnetic polarity interval. We can add that the precision whit which the boundary age is stated (10 ka as demonstrated before) cannot allow the coexistence of the two magnetic conditions. So it is very easy to say that the Vrica microfauna is not coeval to the FAD of *Arctica islandica* den-

ying in this way the «historical» support for the Vrica Boundary. Furthermore all these data further confirm the diachronicity of the appearance of some paleontologic data. We can record that KUKLA et al. (1979) give a radiometric age for the *Arctica islandica* appearance in the Santerno section, age performed on corals of the level of *Arctica islandica*; this age (*1.9 ± 0.1* MA), never discussed, is against the age of Vrica section. This age, in the experimental error, may put the FAD of *Arctica islandica* in the Reunion subzone or at the beginning of Olduvai subzone. Furthermore of *Arctica islandica* is not *in situ,* we cannot know the real age of its appearance that certainly will be older than the ages previously reported. Always in the italian marine series there is the work of CREER et al. (1980) in which the results of a drill, 250 metres deep, near Gioia Tauro in Calabria (les than 150 km from Vrica), are exposed. The paleomagnetic and paleontological data, never quoted but also never denied, show the FAD of *Hyalinea balthica* at an age similar to the age of Vrica N/Q Boundary; at the bottom of the core (Gauss-Matuyama boundary), according to the authors, there is no clear evidence for which the sediments could be attributed to Pliocene. The comparison of Gioia Tauro results to other before reported seems to strengthen the hypothesis of *Arctica islandica* FAD at an age older than 2 MA. Always in the Mediterranean marine series CRAVATTE & SUC (1981, 1982) test the beginning of a steppe phase between the top of *Globorotalia crassaformis* zone and the beginning of *Globorotalia inflata* zone at an age of 2.3 MA. The authors consider this event the first cool floristic event in the Mediterranean, and they compare it to the Praetiglian of North western Europe. But CRAVATTE & SUC do not consider it as the Plio-Pleistocene boundary; they prefer to change the criteria for the boundary rather than change the official Vrica Boundary. But their results are in contrast to official Vrica results: in fact in Vrica the beginning of *Globorotalia inflata* zone is younger, by paleontological and radiometric data, than 2.2 MA; so the biostratigraphical ranges in Vrica section are atypical (JENKINS, 1987, fig. 1) or, the temporal resolution of biostratigraphic zones in the Mediterranean region is, according to the diachronicity of events greater than 100 ka. We think that the method followed to state the N/Q Boundary was the following: the statement of a hypothetical age record on two sections (Santa Maria di Catanzaro and Le Castella), which afterwards resulted in being wrong, some paleontological data corresponding to this age (1.8 or 1.6 MA) has been found in oceanic cores; later these FAD or LAD are reported in Vrica section on which the research to find an age, at any rate, has begun. The paleomagnetism, with a large amount of conflicting data (see NAKAGAWA's works) becomes very precise with the work of TAUXE et al. (1983) in which however the reasons for NAKAGAWA's failure are not explained; when WATKINS (WATKINS et al., 1974) did not agree to NAKAGAWA's results in Santa Maria di Catanzaro, he proved in detail NAKAGAWA's errors. The radiometric age cannot have a real value for geological reasons. There are in Vrica area two different volcanic levels: the older one, about 2.2 MA in age, is very good for age measurements, but it is not related to Vrica section s.s., as, until now, nobody is able to correlate in the field the Stuni section (in which the age was obtained) to the Vrica section in which the Boundary was stated. The younger volcanic level is within the Vrica section: but unfortunally it is a level with reworked

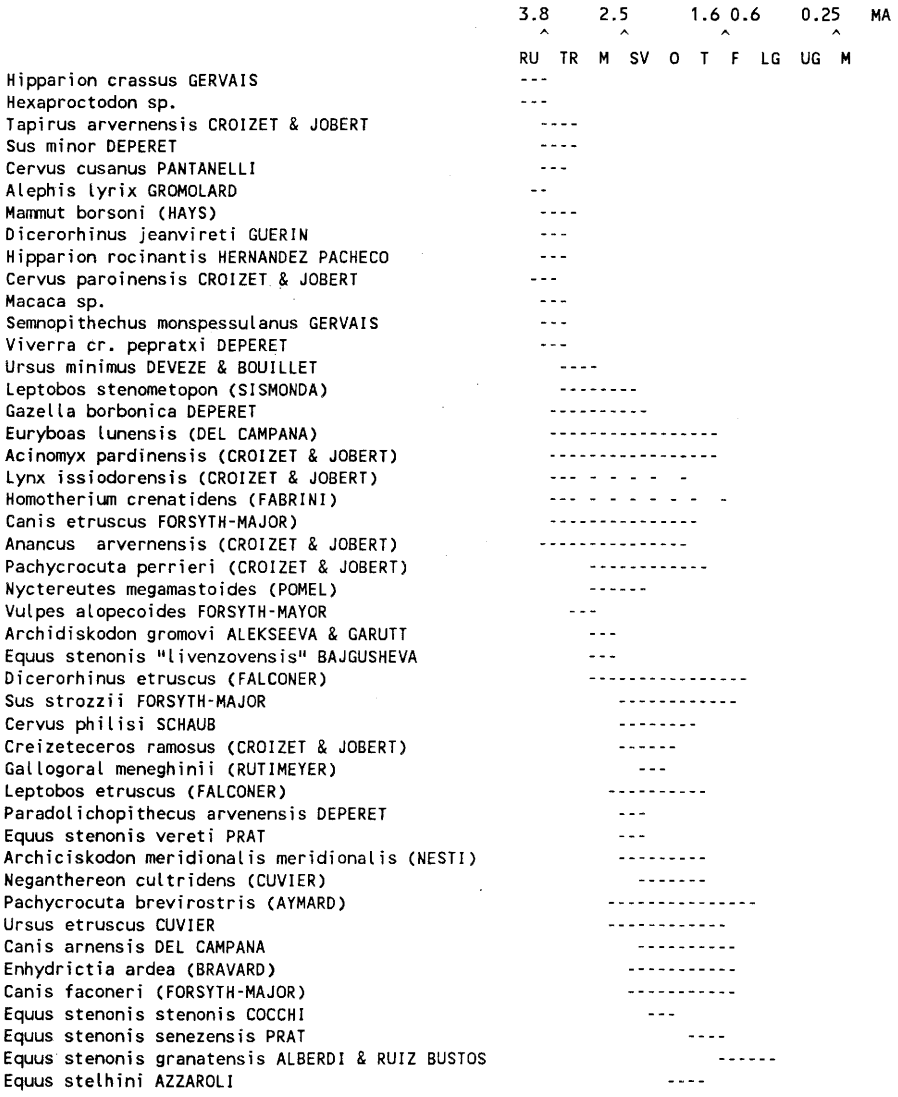
volcanic elements (OBRADOVICH et al. 1982) and on which an age «*younger than* 1.99 ± 0.08 *MA*» was obtained. This value becomes suddenly, without reason much more younger than 1.99 MA in TAUXE et al., (1983, fig. 3). This level is about 25 metres above the proposed boundary and with the proposed sedimentation rate of 310 mm/1000 years the volcanic level would have an age of 1.55 MA. This value would be in good agreement with the hypothetical age of 1.6 MA (OBRADOVICH et al., 1982), but this last value has no geological sense. In fact it is obtained considering as only one section the Stuni section and the Vrica one and calculating the age with the topographical difference in height of the two levels with a stated sedimentation rate: this last value was obtained by the difference in height of the Miocene-Pliocene boundary in the section and the volcanic level 2.2 MA in age. But nobody has proved the geological continuity between the Vrica and Stuni sections. We turn now to the supposed appearance of northern guests at the level of Vrica Boundary: on the coeval appearance of *Arctica islandica* and *Cytheropteron testudo* not all the authors are in agreement (see RUGGIERI, 1976, fig. 1): Only one year after the approval of ICS, BONADUCE & SPROVIERI (1985) proved that *Cytheropteron testudo* appeared in the Pliocene time, 30 metres before *Globorotalia inflata* considered as cold species; but, probably, *Cytheropteron testudo* is a cold species too. Its recent environment is in the Gulf of Biscay at a temperature between 2 and 10 C grades. Its appearance is more or less coeval of the cold *Globorotalia inflata.* In the marine series, not only from an isotopic point of view, but also by a paleontological one, the first cooling is seen, well marked and well recognizable before the Vrica boundary. BIZON & MULLER (1977), MULLER (1978, 1979, 1983) attest to this first cooling, 2.7 - 2.5 MA in age, by the disappearance or the scarcity of discoasters in NE Atlantic and Western Mediterranean regions. SPROVIERI (1986) shows the disappearance of some species and the extinction of almost 22 species of benthic foraminifera in the Mediterranean region at 2.5 - 2.4 MA. The much too precise age of 2.35 MA for the FAD of *Cytheropteron testudo* (we prefer to say about 2.4 - 2.2 MA as reported before on the faunistic temporal resolution) and the other data previously quoted show very well that in the sea as on continents there are strong faunistic changes at an age around 2.5 - 2.3 MA and not at 1.64 MA. In 1976 RUGGIERI, discussing the antecedence between *Arctica islandica* and *Hyalinea balthica* in Quaternary times reported the non-agreement of the authors on this problem, saying that when *Hyalinea balthica* appears before *Arctica islandica.* The RUGGIERI's explanation of this apparent anomaly is based on different bathymetry of the two species (RUGGIERI, 1976, fig. 1). As stated previously, in this scheme the coevity of the appearance of *Cytheropteron testudo* and *Arctica islandica* is dubious. Probably the results of BONADUCE & SPROVIERI (1985) and the paleomagnetic and radiometric data quoted before for italian sections (1.9 ± 0.1 MA is Santerno, *Arctica islandica* FAD in Reunion magnetic subzones) allow one to hypothesize the contemporaneity of the two species (and, probably, of *Globorotalia inflata* too) within the limits of biostratigraphical temporal resolution (about 100 ka).

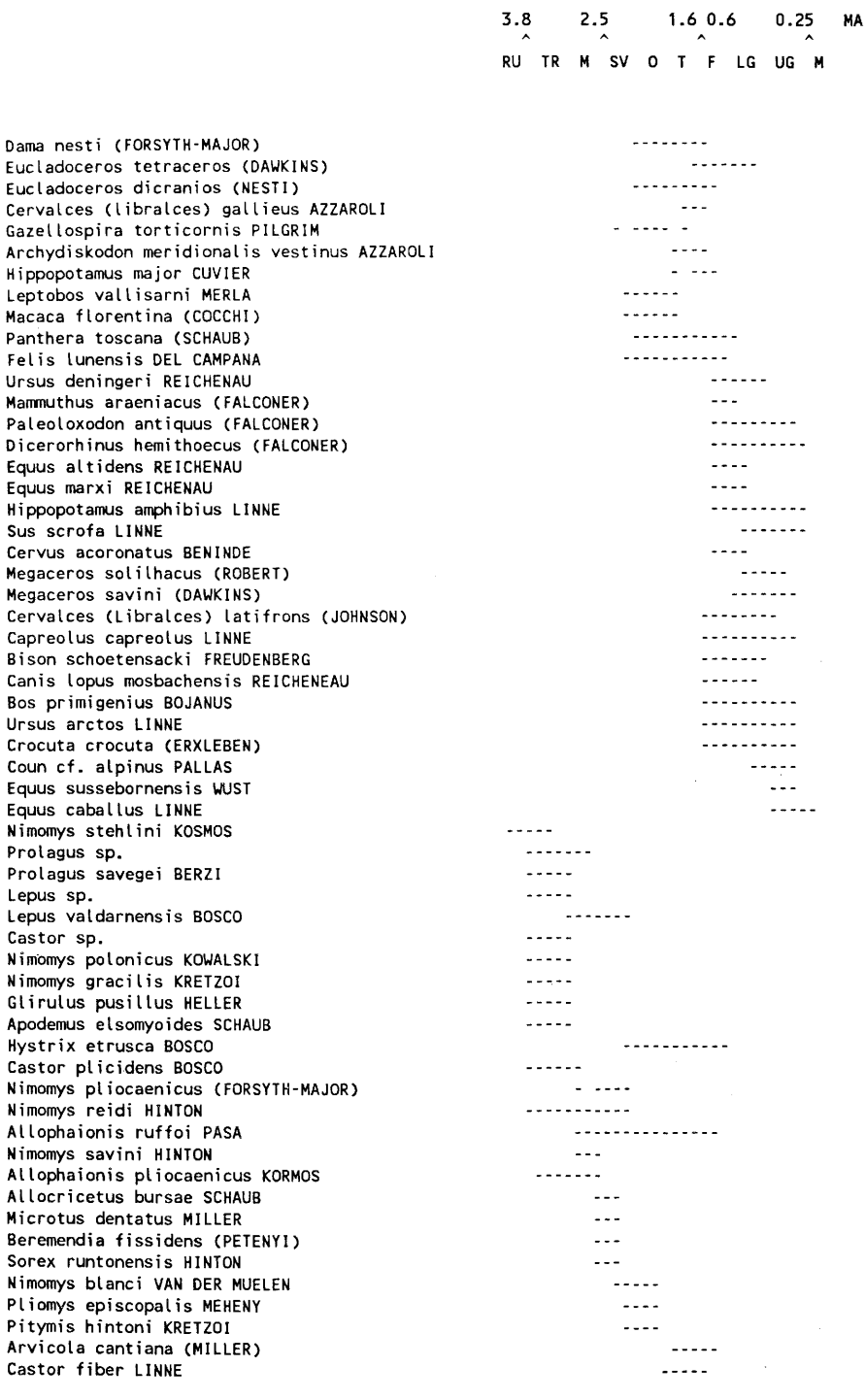
DISCUSSION

In our opinion, therefore, the method to follow to state a geological boundary, particularly the N/Q Boundary, is the opposite to the method followed for Vrica boundary. We have to choise a «geological» event, valid in synchronicity throughout world, and, more important, in all the environments as a climatic change or a change or magnetic polarity or better still, both together, and to see what happens in this period from a paleontological point of view; after this we have to put together the floristic and faunistic changes in the sea and on the continents. The boundary so obtained, in spite of all the type sections, will have an internal consistency throughout world and in all the environments, maintaining its value when speaking about elephants or speaking about nannoplankton. On the basis of the quoted data it is very easy to see that if we settle the climatic event of the first arctic ice growth, working on the paleontological events that happened at that time, we can find all the elements to state a natural boundary and not an artificial one. We think, as WATSON & WRIGHT (1980), that an ideal synchronic boundary for all the world may be used only for Pre-Quaternary, or better pre-neogenic boundaries. The problem to find a type section for Quaternary becomes a pseudo problem due to the attempt to compel in a strictly synchronic chronological building the natural tempo-transgressive events. Our task would be to describe, in the most quantitative way possible, these natural events, to be able to correlate them in a general stratigraphy, but not confined within the strict schemes of chronostratigraphic units of the International Stratigraphic Guide, as these schemes cannot be correlated to Quaternary events. Anyway, we may state the N/Q Boundary at an age of 1.6 MA only if, near this time, «geological» events justifying the transition between two different stages of the Earth's life happened, but we never have to guess in order to define the N/Q Boundary with a temporal precision of 10 ka as happens with the Vrica Boundary. But numerous examples, already quoted, show very clearly only two important «geological» events in the last four million years. The first important cooling at about 2.5 MA and a second less important cooling at less than 1 MA. The first one (2.5 MA) is also marked by strong faunistic and floristic changes in all the environments, as vertebrata turnover, appearance of the first steppe phase, appearance in the Mediterranean area of cold species, extinction, in the sea, of some species or in the oceans or in the Mediterranean region, and by a paleomagnetic reversal (the Gauss-Matuyama boundary); the second cooling (less than 1 MA) is also marked by faunistic changes but less strong than ones of the first event. In our opinion, these have to be the two periods where we can state the N/Q Boundary. Furthermore, taking into account that the appearance, in the Mediterranean region, of cold species begins about around the first cooling, or a little after, we would like to propose the age 2.5 MA for the N/Q Boundary: in this way we keep the Quaternary time as the time during which we have the last strong climatic change in the Earth's life and we keep too the appearance in the Mediterranean region of northern guests to prove this cold time. We also think that we have to leave the age of 1.64 for the Vrica section as stated in an imprecise way, as we think to have demonstrated before, and as in that time (around 1.5 - 1.6 MA) very important «geological» events had not happened.

MAMMAL FAUNA STRATIGRAPHIC DISTRIBUTION IN THE MEDITERRANEAN AREA

RU = Ruscinian (Alcoy, Montpellier, Casino?), TR = Triversa (Triversa, Villarroya, Las Higueruelas), M = Montopoli (Montopoli, Rincón 1, Roca-Neyra?), SV = St. Vallier (St. Vallier, Puebla de Valverde, Anagni-S. Giacomo), O = Olivola (Olivola, Le Coupet, Toledo, Chilhac, Matassino), T = Tasso (Tasso, Cueva Victoria, Casa Frata, Le Ville), F = Farneta (Farneta, Venta Micena, Sainzelles, Blassac, La Malouteyre, Lachar, Fuensanta, Crostolo), LG = Lower Galerian (Ponte Galeria, Solihac, Slivia, Cúllar de Baza), UG = Upper Galerian (Venosa, Fontana Ranuccio, Torre in Pietra, Malagrotta, Castel di Guido), M = Maspinian (Maspino).




3.8 2.5 1.6 0.6 0.25 MA
RU TR M SV O T F LG UG M
Dama nesti (FORSYTH-MAJOR)
Eucladoceros tetraceros (DAWKINS)
Eucladoceros dicranios (NESTI)
Cervalces (libralces) gallieus AZZAROLI
Gazellospira torticornis PILGRIM
Archydiskodon meridionalis vestinus AZZAROLI
Hippopotamus major CUVIER
Leptobos vallisarni MERLA
Macaca florentina (COCCHI)
Panthera toscana (SCHAUB)
Felis lunensis DEL CAMPANA
Ursus deningeri REICHENAU
Mammuthus araeniacus (FALCONER)
Paleoloxodon antiquus (FALCONER)
Dicerorhinus hemithoecus (FALCONER)
Equus altidens REICHENAU
Equus marxi REICHENAU
Hippopotamus amphibius LINNE
Sus scrofa LINNE
Cervus acoronatus BENINDE
Megaceros solilhacus (ROBERT)
Megaceros savini (DAWKINS)
Cervalces (Libralces) latifrons (JOHNSON)
Capreolus capreolus LINNE
Bison schoetensacki FREUDENBERG
Canis lopus mosbachensis REICHENEAU
Bos primigenius BOJANUS
Ursus arctos LINNE
Crocuta crocuta (ERXLEBEN)
Coun cf. alpinus PALLAS
Equus sussebornensis WUST
Equus caballus LINNE
Nimomys stehlini KOSMOS
Prolagus sp.
Prolagus savegei BERZI
Lepus sp.
Lepus valdarnensis BOSCO
Castor sp.
Nimomys polonicus KOWALSKI
Nimomys gracilis KRETZOI
Glirulus pusillus HELLER
Apodemus elsomyoides SCHAUB
Hystrix etrusca BOSCO
Castor plicidens BOSCO
Nimomys pliocaenicus (FORSYTH-MAJOR)
Nimomys reidi HINTON
Allophaionis ruffoi PASA
Nimomys savini HINTON
Allophaionis pliocaenicus KORMOS
Allocricetus bursae SCHAUB
Microtus dentatus MILLER
Beremendia fissidens (PETENYI)
Sorex runtonensis HINTON
Nimomys blanci VAN DER MUELEN
Pliomys episcopalis MEHENY
Pitymis hintoni KRETZOI
Arvicola cantiana (MILLER)
Castor fiber LINNE

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